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spot. The spot was then only partly divided by bridge (a) in diagram. Bridge approaching us.' The other of us happened to examine the same spot independently at 11.50, and reported, 'Hydrogen lines seen reversed across the whole spot. The dark line C was reversed, finely defined on the red side, and extending beyond the C, and indefinite on the yellow side.'

The faculæ are elevated regions, and regions in general of ascent. Prominences and faculæ have the same general cause, and will co-exist, the difference between them being simply one of intensity and of localisation to a smaller area. The spot is the region of descent corresponding to regions of ascent, and will therefore occupy the same belts of surface as prominences.

If this theory be true, the following consequences ought to follow from it, and, therefore, to be observed:—

(1.) The period of maximum sun-spots ought to be identical with that of maximum prominences. The prominences have scarcely been observed long enough to establish whether this is or is not true.

(2.) There ought to be a diminution of the height of the chromosphere in the period of maximum sun-spots. This, we have some reason to believe, is the case.

(3.) In maximum sun-spot periods, the umbra of spots should be larger relatively to the penumbra than in the periods of minimum sun-spots.

(4.) Prominences ought, on the whole, to lean in the direction opposite to that of the rotation of the Sun. From our position, relatively to the solar equator, we can only see this, if it is the case, in spring and autumn; and an examination of all our drawings establishes that this is nearly always the case. The exceptions are very decided lateral jets, which appear to slope indifferently in both directions.

(5.) That faculæ should have a proper motion in the opposite direction to that of a spot.

(6.) That a spot should be more frequently bridged from the West, as we see the Sun, than from the East.

(7.) That there ought to be regions, even near the equator, relatively free from spots for long periods of time; for when disturbance has once begun, it will be long continued. We do not know whether this could be shown from observation.

(8.) The period of spots ought to coincide with that of some assignable cause of disturbance of pressure.

Rugby, 1873, *Nov.* 11.

On the Determination of Time from Sextant Observations.

By William Lassell, Esq.

It is of late but seldom that I have the pleasure of sending to the Society a communication—indeed I have for some time

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ceased to make regular observations with the two-foot equatorial, and what I now do in astronomy is of a very desultory and occasional kind. However, having nearly ceased to observe with a large instrument, I have taken, in this kind of way, to a very small one, and in another department of astronomy—namely, the determination of time.

Since I sent home the Sheepshanks thirty-inch transit instrument, the loan of which I had been permitted to enjoy for some years, I have felt sometimes at a loss for the means of regulating and ascertaining the errors of my clocks—though I had no especial reason for ascertaining their errors within a very small quantity, such as a second or two. But I used many years ago to observe, for determination of time, and occasionally of latitude, with various sextants and circles from six to ten inches radius; and I always found the occupation an interesting one.

The only instrument of this kind I now possess is a small sextant, of only three inches radius, which I purchased from the late Mr. Dollond more than forty years ago. I think he said he had made it for Mr. Davies Gilbert, who for some cause or other had not retained it. The sextant packs in a square box 4·25 inches in the side, and 2·4 inches deep, inside measure. It has a ball-and-socket joint, affixed to a sliding tube, which being screwed into the lid of the box, forms a stand. The telescope, at focus, is 3·4 inches long; and, though it has a clear aperture of only four tenths of an inch, it has two powers, magnifying respectively six and eleven times, defining admirably with the latter, which has quite sufficient light for stars of the second magnitude. The box also contained, when I received it, what professed to be an artificial horizon, being a circular disk about two inches in diameter, of parallel plate-glass, placed in a boxwood cup, to be filled with mercury, the glass disk intended to float horizontally and centrally upon it. But the disk never would remain central; and, though Mr. Dollond introduced four equidistant needle-points to keep it in the centre, it would always be in contact with one or other of the needle-points, thus vitiating its horizontality. I therefore very soon laid it aside.

I afterwards cast and polished a plane speculum, of about the same diameter, mounting it in a brass ring, supported by three equidistant adjusting screws with very fine threads. For levelling this I applied again to Mr. Dollond, and he furnished me with a glass level, the tube about three inches long, and, to quote the inscription upon it—" Ground parallel to show seconds ; " which means that one part of its circumference was ground flat throughout its whole length, and parallel to a tangent to the middle of the internal upper surface of the tube ; so that, when placed upon a horizontal surface, the bubble should be in the middle. I fared no better with this. The level could never be taken up and replaced with a certainty of the same indication ; and reversing might go on for ever without arriving at a uniform or

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consistent result. It became tiresome beyond endurance. The reason seemed to be—either that the ground flat surface of the level was not truly plane; or, invisible particles of dust settled on the speculum, and became attached to the level, or otherwise prevented its coming into true contact with the speculum. That the latter was not in fault was proved by a critical scrutiny of objects reflected in it with a telescope of considerable power.

I then ground some levels myself, and selected one having a scale of 5° of inclination, equal to a displacement of the bubble of two hundredths of an inch, which I mounted in a brass tube with three points or feet. This has proved permanently satisfactory, making the sextant thus complete as a travelling companion. After all, if a vessel of mercury is to be had, and no vibration forbids its use, I always employ it, preferring it to any levelled horizon whatever.

But what has induced me to venture to trouble the Society with all this detail, is that I have found much greater accuracy attainable with these small means than I had expected; and I think it possible that some Fellows of the Society, familiar with this kind of observation, may not be unwilling to hear what can be done with so small an instrument. It may be, however, that others have done as much before, without its having come under my notice; and I merely relate what I confess has excited my surprise.

I proceed now to extract a few observations from my journal.

1873, July 19.—Altitudes for time taken with three-inch sextant, power 11, mercurial horizon, Dollond roof. Times by sidereal watch (= S W) compared with sidereal clock (= S):—

	h m s		s
At	17 19 45	S W − S =	7·0
	19 43 35		5·0
	20 58 12		4·0

Arcturus. 1st mag. West. α Androm. 2nd mag. East. Without roof.

Times.	Altitudes.	Results.	Times.	Altitudes.	Results.
h m s	° ′ ″	s	h m s	° ′ ″	s
18 54 54·4	54 4 30	S. fast 0·5	20 28 22·8	88 41 0	S slow 1·5
58 48·8	52 51 30	0·1	31 20·0	89 36 0	3·8
19 0 32·8	52 19 30	0·7	33 16·4	90 10 30	fast 1·4
2 46·0	51 38 0	0·4	35 19·2	90 48 30	slow 1·7
5 0·0	50 56 0	slow 0·3	37 21·6	91 25 45	1·3
7 19·6	50 12 0	2·7	41 35·6	92 43 0	0·9
		Mean = S slow 0·22			Mean = S slow 1·81

Mean of both sets = S slow $1^s\!\cdot\!01$.

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Index error accounted zero. Approximate position of Ray Lodge, latitude 51° 31′ 23″, longitude $2^{\mathrm{m}}\,49^{\mathrm{s}}{\cdot}3$ west.

1873, July 28.—Same instrument, mercurial horizon and roof. Times by sidereal watch:—

	h	m	s		s
S =	17	59	43	S − S W =	43·0
	19	40	52		43·6
	21	13	52		44·4

α Coronæ. 2nd mag. West.

Times.			Altitudes.				Results.
h	m	s	°	′	″		s
20	3	59·6	67	37	30	= S slow	22·0
	10	44·2	65	32	15		21·0
	13	36·8	64	39	0		20·1
	15	48·4	63	59	0		17·6
	17	54·0	63	19	30		19·7
	20	30·4	62	31	0		19·8
	22	20·4	61	57	0		19·8

Mean = S slow 20·0

α Androm. 2nd mag. East.

Times.			Altitudes.				Results.
h	m	s	°	′	″		s
20	40	33·2	92	46	0	= S slow	24·9
	43	8·0	93	31	15		19·2
	45	33·6	94	16	30		23·0
	49	59·6	95	36	30		22·2
	52	27·6	96	20	30		20·5

Mean = S slow 21·96

Mean of both sets = S slow $20^{\mathrm{s}}{\cdot}98$.

August 21.—Altitudes as before for time. Mercurial horizon without roof. Times by sidereal watch. S − S W = $1^{\mathrm{m}}\,59^{\mathrm{s}}{\cdot}5$:—

α Androm. 2nd mag. East.

Times.			Altitudes.				Results.
h	m	s	°	′	″		s
20	36	20·8	91	48	30	= S slow	12·9
	39	5·6	92	39	0		14·1
	41	20·8	93	20	0		13·9
	43	55·6	94	7	0		14·3

Mean = S slow 13·80

α Coronæ. 2nd mag. West.

Times.			Altitudes.				Results.
h	m	s	°	′	″		s
21	3	29·2	49	0	0	= S slow	13·6
	6	38·8	48	2	30		14·5
	8	54·8	47	22	0		13·5
	10	44·4	46	49	30		11·9
	13	21·2	46	1	30		15·1

Mean = S slow 13·72

Mean of both sets = S slow $13^{\mathrm{s}}{\cdot}76$.

Sept. 1.—Same instrument. Mercurial horizon without roof:—

	h	m	s		s
S =	20	54	34	S W − S =	42·0
	22	1	38		42·0
	23	52	52		43·6

Index error = + 20″

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α Coronæ. 2nd mag. West.

Times. h m s	Altitudes. ° ′ ″		Results. s
21 15 25·6	46 7 0	=S slow	32·7
19 48·8	44 48 0		33·1
22 30·0	44 0 0		33·3
24 36·4	43 22 15		33·5
26 51·2	42 42 30		32·7

Mean = S slow 33·06

Capella. 1st mag. East.

Times. h m s	Altitudes. ° ′ ″		Results. s
22 44 57·6	62 37 30	=S slow	33·9
51 51·6	64 22 30		34·2
54 17·6	65 0 0		34·9
56 45·6	65 38 0		34·9
23 0 0·0	66 28 0		34·5

Mean = S slow 34·48

Mean of both sets = S slow 33·77.

α Arietis. 2nd mag. East.

Times. h m s	Altitudes. ° ′ ′		Results. s
22 18 45·6	78 8 30	=S slow	33·5
24 48·0	79 58 30		34·4
27 44·0	80 50 0	windy	29·2

Mean = S slow 33·37

ζ Herculis. 3·2 mag. West.

Times. h m s	Altitudes. ° ′ ″		Results. s
21 32 48·0	67 57 0	=S slow	28·3
35 33·6	67 6 15		29·0
38 15·2	66 16 45		29·4
40 58·0	65 26 30		31·3
43 38·0	64 38 30		29·1

Mean = S slow 29·42

Mean of both sets = S slow 31s·40.

The last two sets of altitudes I should not depend much upon; and they are introduced principally to show the probable error under unfavourable circumstances, ζ Herculis not being bright enough, in the then state of the sky, and the altitudes of α Arietis being too few, and those disturbed by wind. Also a reason for rejecting α Arietis is the danger, without extreme care, of making α and β to osculate.

Sept. 22.—Mercurial horizon without roof. Sky hazy — increasingly so—so that at the close Capella was too dim to enable me to determine the index error. The index error, however, of this sextant is very small and very constant. Times by sidereal watch:

	h m s		s
S =	22 22 44	S W − S =	44·0
	23 56 47		45·4

α Lyræ. 1st mag. West.

Times. h m s	Altitudes. ° ′ ″		Results. s
22 46 50·0	89 57 0	=S slow	11·8
50 22 8	88 52 30		9·8
54 10·4	87 41 45		13·6
56 41·6	86 56 30		10·6
59 36·0	86 2 0		14·7
23 2 25·2	85 11 0		13·4

Mean = S slow 12·32

Capella. 1st mag. East.

Times. h m s	Altitudes. ° ′ ″		Results. s
23 18 54·8	71 19 30	=S slow	12·6
22 23·2	72 16 0		15·9
26 52·0	73 27 0		11 8
29 28·4	74 10 0		15·2
33 1·2	75 7 30		14·7
36 21·2	76 1 30		13·4

Mean = S slow 13·93

Mean of both sets = S slow 13s·12.

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The discrepancies of the individual altitudes will not seem extravagant when it is remembered that Capella, for instance, while these were taken, was rising about 16″ of altitude in one second of time, the sextant only reading to 30″; and I may add to this my deteriorated vision, by which I am often sorely puzzled to read off the sextant in any degree to my satisfaction. I think it unnecessary to add that there are *no altitudes rejected*, the whole series being given; and that the whole of the observations are, I believe, as far from being 'cooked' as is possible. It is my practice to work out each altitude separately; as, if grouped together and the mean of the altitudes and times taken, a blunder in one observation would be masked and might vitiate the whole. The altitudes of this evening, thus treated, give for α Lyræ S. slow $12^{s}\cdot0$, and for Capella $15^{s}\cdot3$ mean = $13^{s}\cdot6$, agreeing within about half a second with the mean of the individual results. When there is a perceptible breeze I do not hesitate to use the Dollond roof, generally taking half the number of altitudes with the roof in a given position, and reversing it for the other half. I do not find, however, any sensible error traceable to the roof. Altitudes of the Sun I very rarely take; for, although it is a more agreeable and easier operation, and the sextant is more accurately read by sunlight than lamplight, there is the disadvantage of not having any other heavenly body whose altitude can be taken at about the same time, to balance or correct the solar observation.

For keeping and carrying on my time, when I have got it, I generally use a mural transit, being a telescope firmly braced to a thick wall, and directed approximately to the equator, and within a few seconds of the meridian; its exact deviation from which having been originally determined and occasionally verified by sextant observations. The object-glass is an excellent one of 2·20 inches aperture and 25·8 inches focus, the eye-piece magnifying 32·6 times. It has three rather stout wires, about 40 seconds apart, and is furnished with the means of illumination. The field of view is large, and, by means of a positive eye-piece sliding vertically, it embraces all stars between about 88° 15′ and 91° 45′ polar distance. My observing list includes about 170 stars, not lower than the seventh magnitude of the British Association Catalogue. Of this magnitude, however, only about 27 are introduced in parts of the sky rather bare of larger stars, and these are abundantly bright even in a somewhat hazy and dull sky.

The annual precessions are stated in my transit-list, and the corrections of R.A. due to the season of the year are obtained by inspection from a short supplemental table. Of course I do not pretend thus to ensure the extremest accuracy, my requirements generally being satisfied with the belief or conviction that the probable error of any determination does not exceed one second. The large number of stars passing ensures, even on a fitful night, frequent opportunities of observation.

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I have made with the sextant above described equally coincident observations for determination of latitude, but with these I do not think it necessary to trouble the Society.

Ray Lodge, Maidenhead, 1873, *November* 10.

On a New Driving Clock for Equatorials. By Lord Lindsay and David Gill, jun.

One of the most important adjuncts of the modern equatorial is the driving clock. Formerly the equatorial was merely expected to carry a small and light micrometer, and that with only moderate accuracy for a short time.

Now spectrum analysis and celestial photography demand a higher accuracy of rate, and that maintained for a considerable time.

Not only is it so, but this accuracy has to be attained under more unfavourable circumstances. Modern spectroscopes are of such considerable weight, and so unsymmetrical in shape, that it is difficult or impossible to maintain in all circumstances a perfect counterpoise of the equatorial.

From these considerations we endeavoured to realise the following conditions, in contriving a clock-motion for the great equatorial of the Dunecht Observatory.

1. A driving power four or five times as great as that actually required, so as to avoid failure when the balancing of the instrument is defective.
2. A rate of motion equal in accuracy to that of a good sidereal clock.
3. Maintenance of the same uniformity of rate under change of work to be done, twice as great as that to which the clock will be likely to be submitted.
4. An easy and rapid means of adjusting that rate and so avoiding delay in timing as much as possible.

The first of these conditions was easily attained by the employment of a large and powerful clock capable of being driven by a very heavy weight as in the accompanying sketch. The last three conditions are at once fulfilled by controlling a rotatory governor by a swinging pendulum, the latter being controlled electrically by the standard clock of the Observatory.

The Bonds in America, and the late Mr. Cooke of York, have both contrived clocks in which the rotation of a fan is controlled by a swinging pendulum, but in neither of these arrangements is the control perfect. In either construction a moderate increase of the driving weight will cause the clock to *run up* a certain amount before the control of the swinging pendulum is sufficient to overcome the increased tendency to gain. The effect of such